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OFFICE OF
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TOXIC SUBSTANCES

Memorandum

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SUBJECT: Biological and Economic Analysis of Diazinon on Lettuce

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SUMMARY

Based on available published information and personal communications with crop experts, BEAD believes that cancellation of the diazinon use for controlling soil insects on lettuce will have a major impact on both head and leaf lettuce production, since there are no suitable alternatives available, and yield losses without diazinon could be as high as 25% in some localities. Cancellation of diazinon would thus result in major economic losses to lettuce growers from insect damage, ranging from 45% of net revenues in Arizona to as much as 90% for affected acreage in California. Nationally, BEAD calculates annual losses to the lettuce industry as high as $34.9 million. The impact of diazinon cancellation for aphid control on head lettuce is expected to be minor, since four alternatives exist, and minor to moderate on leaf lettuce, for which available

alternatives are limited to imidacloprid, an effective but expensive aphicide, and dimethoate, an inexpensive but less effective insecticide. Without diazinon, economic losses from aphid damage stem mainly from more costly control methods. Minor losses of 2.5 to 3.2% of grower net revenues are expected. Aphids are primarily a problem in California, where total losses to the industry are calculated at $940,000. Total cost to the nation's lettuce industry from both pest complexes could be as much as $35.8 million or 2% of gross revenues.

LIMITATIONS AND SCOPE OF ANALYSIS

The scope of this analysis includes an examination of potential regional-level impacts associated with elimination (through a phase-out) of the use of diazinon on lettuce. This mitigation scenario reflects the high health risks to mixers, loaders and applicators as identified by the Health Effects Division of the Office of Pesticide Programs. This analysis does not attempt to address impacts associated with mitigation efforts targeted at workers reentering fields treated with diazinon, or potential mitigation for various environmental risks (i.e., risk mitigation for risks to terrestrial plants and organisms or water contamination).

There are limitations to this assessment. The impacts estimated by this analysis only represent potential short-term – 1 to 2 years – impacts on the lettuce production system and grower returns. National impacts are calculated by simply scaling up the estimated per-acre impacts. We ignore potential changes in price that may result from production changes and the grower impacts we estimate assume there will be no shift from lettuce to other crops.

Assumptions about yield and quality losses associated with the various scenarios are based on the best professional judgement of BEAD analysts when estimates were not available from other sources. Assumptions are based on a review of available USDA crop profiles, state crop production guides, discussions with university extension and research entomologists knowledgeable in lettuce production, and other sources listed. Lettuce production is a very complex system that can be influenced by a variety of parameters (e. g., weather). BEAD's ability to quantitatively capture the wide array of events that could unfold given each hypothetical scenario listed above is very limited.

LETTUCE PRODUCTION

U.S. lettuce production is a $1.7 billion dollar industry comprised of head (iceberg) lettuce and leaf lettuce (including romaine) (USDA/NASS, 2001). Production is concentrated in Arizona and California, where lettuce is grown under irrigated conditions. Table 1 provides average acreage, production and value for the most recent three years for the different types of lettuce. Head lettuce production makes up almost 73% of U.S. lettuce production by weight and over 65% by value. California is the largest producer with 75% of total production and value. Arizona produces more than 20% of total production, with relatively higher production of head than leaf lettuce. Colorado and New Jersey also produce head lettuce, while Florida and New Jersey produce both leaf and romaine, but, combined, these states produce less than 2% of total lettuce.

The U.S. lettuce exports total about 325,000 metric tons with a value of $175 million (FATUS, 2001). Canada is the principal market, importing over 270,000 metric tons or 83% of the total. The U.S. does import small amounts of lettuce, about 27,000 metric tons, of which about 11,000 metric tons comes from Mexico and almost 16,000 metric tons from Canada.

Table 1. Lettuce acreage, production and value, 1999-2001 averages.

	harvested acres	production (1000 cwt)	yield (ton/acre)	value ($1000)	farmgate price ($/cwt)
Arizona	**67,133**	**23,300**	**17.4**	**378,479**	**16.24**
head	50,670	18,158	17.9	254,937	14.04
leaf	5,070	1,468	14.5	49,446	33.69
romaine	11,400	3,675	16.1	74,096	20.16
California	**217,667**	**72,500**	**16.7**	**1,331,292**	**18.36**
head	135,670	51,530	19.0	866,496	16.82
leaf	45,670	9,945	10.9	260,403	26.18
romaine	36,330	11,025	15.2	204,393	18.54
U.S.	**291,170**	**97,431**	**12.8**	**1,736,825**	**17.83**
head	190,630	70,820	18.6	1,139,221	16.10
leaf	51,430	11,525	11.2	312,378	27.10
romaine	49,310	15,086	15.3	285,226	18.91

Source: USDA, Vegetables 2001 Summary, January 2002

USE OF DIAZINON ON LETTUCE

BEAD (2000) previously estimated diazinon use as approximately 45,000 lb. active ingredient (a.i.) annually on 57,000 acres of head lettuce and 14,000 lb. a.i. annually on 18,000 acres of leaf and romaine lettuce (BEAD, 2000). BEAD estimated approximately 28% of acreage in head lettuce and 32% of other lettuce treated with diazinon. The most recent USDA Chemical Usage Report (2001) reports that 45% of head acreage was treated with diazinon, and 51% of leaf and romaine lettuce was treated. Insecticide use is highly variable, however, as it responds to specific pest outbreaks. In 1998, percent crop treated was 16 for head and 24 for leaf and romaine (USDA, 1999). A weighted average of the last three reports from USDA, covering 1996, 1998 and 2000, suggests that 28% of head lettuce and 36% of leaf and romaine lettuce are treated.

The average amount of diazinon applied annually in the U.S. to lettuce over the years covered by USDA is 40,800 lb. a.i. to head lettuce and 37,100 lb. a.i. to other lettuce. This is reflective of recent shifts in production away from head lettuce, with a decline of approximately 10,000 acres, toward other lettuce, which increased by almost 42,000 acres over the past five to ten years. Diazinon is used relatively more intensively on leaf and romaine lettuce, with an application rate of about 1 lb a.i. per acre per year, compared to 0.75 lb a.i. per acre per year on head lettuce.

California is the primary user of diazinon by virtue of having the largest lettuce acreage of producing states. Diazinon use is relatively higher as well. USDA data indicates that about 33% of head lettuce acreage and 39% of other lettuce acreage in California is treated. Total lb. a.i. applied is approximately 62,200 annually,

with about 34,100 applied to head lettuce and 28,100 applied to leaf and romaine. Data for Arizona are not reported for all years, but it can be inferred that usage is approximately 8,700 lb. a.i. annually, with about 6,700 lb. a.i. applied to head lettuce. BEAD also estimates that about 13,000 acres of lettuce in Arizona is treated with diazinon annually, representing approximately 19% of the harvested area.

Diazinon is available as emulsifiable concentrate, wettable powder, and granular formulations. For control of aphids, lygus bugs, and other leaf-feeding insects, liquid diazinon is applied by air or ground equipment. Granular or liquid diazinon is broadcasted and then incorporated into the soil before or during planting to control soil insects.

TARGET PESTS

Diazinon is used primarily to control two broad categories of insects pests of both leaf and head lettuce. One group, collectively known as "stand establishment pests," includes the seed corn maggot, springtails, the garden symphylan, cutworms, wireworms, crickets, and several ground-dwelling beetles, all of which are chewing insects. The other group includes aphids and, to a lesser degree, lygus bugs, all sucking insects.

Stand establishment pests can be especially damaging to emerging seedlings and young lettuce plants, which may not survive their attack. Although soil insects are less of a threat to a mature plant, the damage inflicted can render the affected plant unmarketable. In Arizona, where lettuce is grown in the irrigated desert, diazinon is used to control several soil insects, including field crickets (*Gryllus*), darkling beetles (*Blapstinus*), and flea beetles (*Phyllotreta, Epitrix*). Darkling beetles girdle young plants at soil level, crickets chew large portions of leaf, and flea beetles chew small round holes in leaves. Although their distribution and abundance is highly variable, these insects may rapidly destroy most of a severely infested field, if uncontrolled (Crop Profile for Lettuce in Arizona, 2000). In the California coastal valleys, damage in individual lettuce fields by springtails (Collembola), the garden symphylan (*Scutigerella immaculata*), cutworms (*Agrotis, Feltia, Peridroma*), and the seed corn maggot (*Delia platura*) can also be as high as 25% in heavily infested fields (W. Chaney, B, Platts, personal communication). Diazinon, applied preplant, at about 2 lb a.i./acre, is the only product registered to control the entire soil insect complex.

Aphids can be a problem in most of California's lettuce growing regions. Aphids cause damage by feeding and by excreting honeydew, which in turn encourages sooty mold. In addition, high aphid populations can stunt young plants and reduce yields. Aphids can also transmit the lettuce mosaic virus. The two species most commonly controlled by diazinon on leaf and head lettuce are the green peach aphid (*Myzus persicae*) and, to a lesser extent, the potato aphid (*Macrosiphum euphorbiae*). Occasionally, diazinon is also used to control the lettuce aphid (*Nasonovia ribis-nigri*), although with limited effectiveness. Less widespread than aphids, lygus bugs (*Lygus hesperus*) occasionally infest lettuce fields in parts of central California, causing dark, sunken lesions on the leaves and reducing the marketability of the crop. In Monterrey County, lygus bugs may be a problem from approximately mid April through early June.

In Monterrey County, which leads California in lettuce production (106,173 acres grown in 2000, including 48,373 acres of leaf lettuce), aphids can affect close to 100% of the acreage. In this region, where farmers rely mainly on diazinon for aphid control on leaf lettuce, less effective insecticides may have to be applied, and more often, to achieve the same degree of control (B. Platts, personal communication). Diazinon is not used much for aphid control in the Imperial Valley of California, partially because in this region imidacloprid

is applied to control whiteflies on early season lettuce, and these treatments also control aphids. In New York, yield losses can be up to 25% in severely aphid-infested fields (USDA Crop Profile for Lettuce in New York, 1999).

ALTERNATIVE CONTROL METHODS

There are at least four alternatives available for control of the green peach and potato aphids on head lettuce, three of which are organophosphates (acephate, dimethoate, and oxydemeton-methyl) and the fourth, a neonicotinoid (imidacloprid). Of these, acephate is perhaps the most cost effective foliar treatment for both aphid and lygus bug control [USDA Crop Profile for Lettuce (Iceberg) in California, 2001]. Oxydemeton-methyl, another effective aphicide, is less widely used than diazinon or acephate, probably because of its relatively higher cost. Dimethoate, an inexpensive but only moderately effective aphicide, is used less frequently than diazinon or acephate. Imidacloprid, an expensive but effective systemic aphicide is frequently used as preplant soil application or as foliar application to control several aphids, including the lettuce aphid in California's coastal valleys.

Two of the more effective OP insecticides registered for use on head lettuce, acephate and oxydemeton-methyl, are not registered for use on leaf lettuce. Thus, the only alternatives available for aphid control on leaf lettuce are imidacloprid and dimethoate. As discussed above, imidacloprid is more expensive than diazinon, and dimethoate is reported as being less effective against aphids than either diazinon or imidacloprid (B. Platts, personal communication).

Endosulfan, malathion, and insecticidal soaps are also registered for aphid control on lettuce, but none is a suitable diazinon alternative. Endosulfan, is an effective aphicide, but has limited use, especially in the coastal regions of California, because of restrictions due to its high toxicity to aquatic organisms. In Monterrey County it may not be used in about 12,000 acres of lettuce. Malathion has limited effectiveness as an aphicide. Insecticidal soaps, although effective if properly applied, are seldom used because their short residual activity and mode of action require multiple applications and complete plant coverage. Although aphids have many natural enemies, natural control is inadequate to achieve the degree of control needed on lettuce, as high quality market standards do not allow insect contamination.

Alternative insecticides available for lygus bug control are acephate (head lettuce only), methomyl, cypermethrin, dimethoate, lambda-cyhalothrin, malathion, methomyl, permethrin, and tralomethrin.

There are no suitable alternatives for controlling the entire soil insect complex affecting both head and leaf lettuce. Sometimes, pyrethroids are applied for this purpose, but results are seldom satisfactory. A carbaryl bait formulation is available for cutworm control, but it is does not target other soil insects.

BIOLOGICAL IMPACT OF DIAZINON CANCELLATION FOR LETTUCE

Diazinon is used on head and leaf lettuce primarily to control soil insects and aphids, two of the more important pest groups affecting lettuce. Other pests controlled by diazinon include lygus bugs and leaf beetles. In the main lettuce-producing states, California and Arizona, soil insects may cause up to 25% yield losses if not controlled. In New York, yield losses from aphid damage are reported to be as high as 25% in heavily infested fields, although given the availability of insecticides registered for this use, such extreme losses are probably uncommon. Other than diazinon, there are no effective alternatives at present for

controlling the wide range of stand establishment pests that affect all lettuce varieties. Diazinon is less necessary for aphid control on head lettuce since at least four alternatives are available for this use. However, because two of these insecticides, acephate and oxydemeton-methyl, are not registered for use on leaf lettuce, cancellation of diazinon would leave only one effective but expensive alternative, imidacloprid, and another less expensive but not as effective alternative, dimethoate. On this basis, and considering the high quality standards on lettuce for insects or insect damage, the availability of diazinon for aphid control on leaf lettuce is highly desirable.

ECONOMIC IMPACT OF DIAZINON CANCELLATION FOR LETTUCE

A partial budget approach was used to determine the economic impact of diazinon cancellation on lettuce producers. Sample production costs were obtained from the Agricultural Cooperative Extension programs of the University of Arizona and the University of California. These budgets are reflective of the likely incurred costs, but are not based on cost of production surveys. This analysis assumes that farm gate prices are not affected by any changes at the grower level and that growers do not drastically alter their other production practices. We focus solely on operating costs, ignoring overhead and land rent, as these are difficult to measure. Thus net cash returns overstate actual returns to the grower.

Historical yield and price data were utilized to determine gross returns per acre. Table 2 presents gross returns, production costs and net cash returns to head lettuce production in Maricopa County, Arizona. Yields have averaged over 17.9 tons/acre over the past several years, ranging from 16.7 to 19.5 (USDA, 2001). Without effective alternatives to replace diazinon for the control of soil insects, yields could decline by as much as 25%, to 13.4 tons/acre. The price of $280.80/ton is a weighted average of 1999-2001 prices and implies a price of $6.60 per 47-pound carton. According to the estimated crop budgets, insecticide costs cover seven applications throughout the year, including one at stand establishment. EPA data provides a weighted average per acre cost of diazinon of $9.23, including labor costs for the application. Farmers would save this cost. In addition, harvest costs would decline since some costs, such as packing and hauling, are based on the number of cartons produced. As shown in Table 2, BEAD estimates cost savings of nearly $450/acre, or about 14% of total operating expenses. Despite savings in harvest cost, losses in net cash returns would be substantial. Growers could incur losses of over $800/acre, nearly 45% of their cash income. This probably represent the maximum potential losses.

Table 2. Gross Returns, Production Costs and Net Returns to Head Lettuce Production, Arizona, with outbreak of soil insects.

	Base Scenario Diazinon for Control of Soil Insects	No Alternative	Percent Change
Production (tons/acre)	17.9	13.4	-25.0
Price ($/ton)	280.80	280.80	
Gross returns ($/acre)	5031.64	3773.73	-25.0
Diazinon ($/acre)	9.23		
Other pre-harvest costs ($/acre)	655.12	655.12	

Harvest costs ($/acre)	2554.38	2115.94	-17.2
Total operating costs ($/acre)	3218.72	2771.05	-13.9
Net cash returns ($/acre)	1812.92	1002.68	-44.7

Source: BEAD/EPA estimates.

The situation in California is similar. Average yields of head lettuce are slightly higher, 19 tons/acre, and prices have averaged $7.06 for a 42-pound carton. Thus, gross returns in California are about $6400/acre. Operating, and particularly harvest, costs are higher in California, leading to a lower return per acre of $556.73. Again, we assume a maximum yield loss of 25% to soil insects if diazinon is cancelled. Gross returns could fall to $4800/acre, assuming no price changes. The cost of diazinon applications are somewhat higher in California than in Arizona; EPA data indicates an average cost of $14.88/acre, which would be saved as no effective alternatives for soil pest are available. Certain harvest costs would also decrease due to lower yields, but net cash returns would fall by over $500/acre or 90% to less than $50/acre. It is unlikely that lettuce producers could remain in operation under these conditions.

Leaf lettuce production in California would also be impacted. Returns are higher for leaf lettuce production, given a higher price of $9.16 per 35-pound carton. A 25% yield loss, however, from 10.9 tons/acre to 8.2, would ultimately result in a 70% decrease in net cash returns, despite reductions in chemical and harvest costs. BEAD estimates losses per acre at $935.90.

Cancellation of diazinon would have less impact on growers who use it for aphid control because alternatives, while more expensive, exist. Table 3 provides sample production costs for head lettuce in Monterey and Santa Cruz counties, showing the base scenario with aphid control using diazinon compared to acephate, which also provides good control and is less expensive than imidacloprid or oxydemeton-methyl. No yield impacts are expected, but aphid control costs increase almost three-fold. Both chemicals are expected to be applied twice during the growing season, diazinon at a rate of 0.5 lb. active ingredient (a.i.) per acre and acephate at 0.75 lb. a.i./acre. Total operating costs increase $17.50/acre or 0.3%. Net cash returns fall from $557/acre to under $540/acre for a decline of 3.2%.

Table 3. Gross Returns, Production Costs and Net Returns to Head Lettuce Production, California, with aphid infestation.

	Base Scenario Diazinon for Control of Aphids	Alternative Acephate	Percent Change
Production (tons/acre)	19.0	19.0	0.0
Price ($/ton)	336.00	336.00	
Gross returns ($/acre)	6389.84	6389.84	0.0
Diazinon ($/acre) Acephate ($/acre)	6.88	 24.42	 254.9
Other pre-harvest costs ($/acre)	1528.61	1528.61	
Harvest costs ($/acre)	4297.62	4297.62	

Total operating costs ($/acre)	5833.11	5850.65	0.3
Net cash returns ($/acre)	556.73	539.19	-3.2

Source: BEAD/EPA estimates.

Leaf lettuce growers would be obligated to switch to imidacloprid because acephate is not registered for use on leaf lettuce. They would therefore face even higher increases in costs because imidacloprid, at 0.05 lb. a.i./acre costs approximately $14 and would need to be applied twice during the growing season. Operating costs would increase about 0.5% and net cash returns would drop from $1337/acre to about $1315/acre, a decline of 2.5%.

Regional Impacts

Aphids are not generally a problem in Arizona, nor in the similar desert production region of California. Some growers, especially in the coastal regions of California, may face both soil pest and aphid problems. While cancellation of diazinon would result in negligible economic impacts for growers with aphid problems, it would result in major losses to producers with soil insect problems of 45 to 90% of net revenues since effective alternatives for soil pests are unavailable.

BEAD estimates that 13,000 acres of lettuce are treated with diazinon in Arizona, all of which is assumed to be for soil pests. With maximum losses estimated at $800/acre, the Arizona lettuce industry could face losses as high as $10.4 million annually out of $378.5 million in gross revenues. Production losses could total nearly 57,000 tons out of 1.2 million tons. This could result in price increases that would offset some losses to the producer, but would result in losses to consumers from higher lettuce prices.

Approximately 76,800 acres of lettuce are treated annually with diazinon in California. EPA data suggest that about 64% of this acreage, 49,200 acres, are treated for aphids and 48%, 36,900 acres, are treated for soil insects. This implies that some acreage is treated for both. Assuming that pests strike lettuce acreage in the same proportion it is planted, about 23,000 acres of head and 13,900 acres of leaf lettuce are treated for soil pests. Multiplying estimated per acre losses associated with cancellation of diazinon by these figures result in annual state-wide losses of as much as $24.5 million due to soil insects. Similar calculations for aphid control result in a yearly loss of $940,000. Total losses for the state are nearly 2% of the gross value of production.

Together, annual losses to the lettuce industry from a cancellation of diazinon would total $34.9 million from soil insects and $0.9 million due to higher costs of controlling aphids. These losses are summarized in Table 4. The smaller growing regions would also be expected to incur some losses. These losses are 2% of the total revenues for the industry.

Table 4. Potential economic losses from cancellation of diazinon on lettuce.

	Soil Insects/At Plant		Aphids/Growing Season	
	Area Impacted	Losses ($ million)	Area Impacted	Losses ($ million)
Arizona	13,000	10.4		

California	36,900	24.5	49,200	0.9
Total	49,900	34.9	49,200	0.9

Source: BEAD/EPA calculations.

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